Announcements

- Homework for tomorrow…

  Ch. 31: CQ 10, Probs. 20, 22, & 46

CQ3: $\Delta V_{12} = 3V$
31.1: See whiteboard
31.6: 8V, 22V
31.8: (48/25)W, (72/25)W

- Office hours…

  MW 10-11 am
  TR 9-10 am
  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm
  F 8-11 am, 2-5 pm
  Su 1-5 pm

Chapter 31

Fundamentals of Circuits

(*Real Batteries & Parallel Resistors*)

Review…

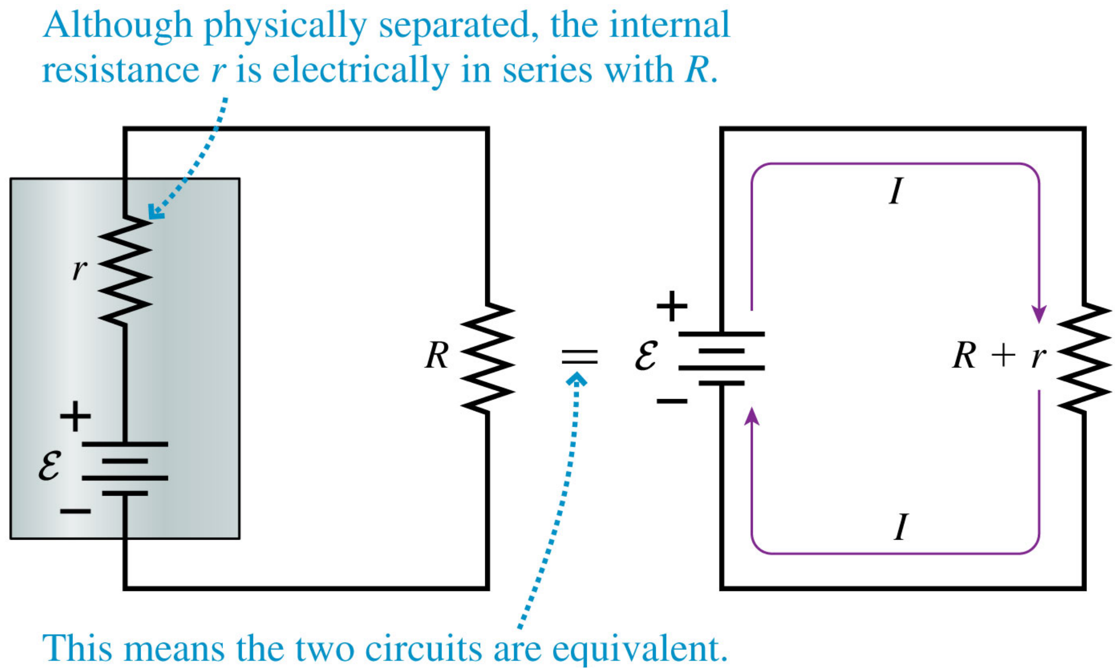
Resistors in *series*….

$$R_{eq} = R_1 + R_2 + \ldots$$

Terminal voltage across a *real* battery…

$$\Delta V_{bat} = \mathcal{E} - Ir \leq \mathcal{E}$$

31.5:
Real Batteries



Notice:

$\Delta V_R = \Delta V_{bat}$, $\Delta V_R \neq \mathcal{E}$

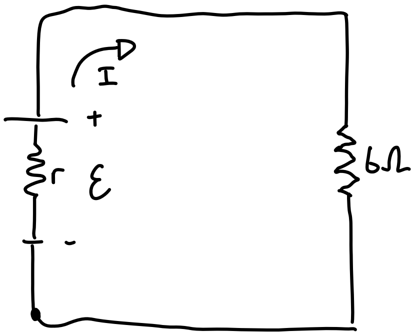
i.e. 31.6:
Lighting up a flashlight

A 6.0Ω flashlight bulb is powered by a 3.0V battery with an internal resistance of 1.0Ω.

What are the power dissipation of the bulb and the terminal voltage of the battery?

$P_R = ?$
$\Delta V = ?$

$R = 6.0\,\Omega$
$\mathcal{E} = 3.0\,V$
$r = 1.0\,\Omega$



$3.0V - I(r) - I(R) = 0$
$I(r + R) = 3.0V$
$I = \frac{3.0V}{r+R}$
$I = 3/7\,A$
$I = 0.43A$

$P_R = I^2 R$
$= (0.43A)^2(6\Omega)$
$P_R = 1.1\,W$
$\Delta V = 2.6$

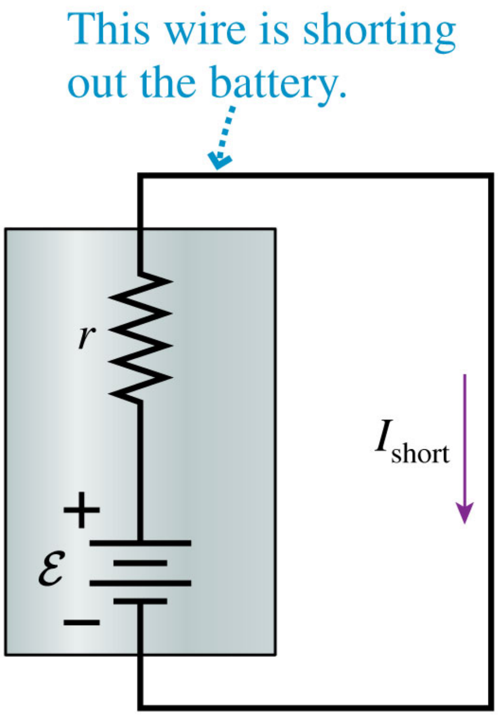
$\Delta V_B = \mathcal{E} - Ir$
$\Delta V = 3.0V - I(r)$
$= 3.0V - 0.43A(1\Omega)$
$\Delta V = 2.6\,V$

A Short Circuit…

What is the current in this circuit?

$\mathcal{E} - I_s r = 0$

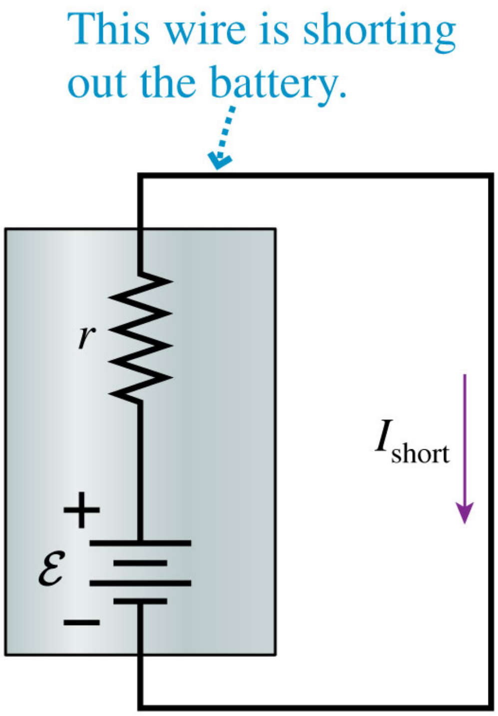
$I_s = \dfrac{\mathcal{E}}{r}$



A Short Circuit…

What is the current in this circuit?

$$I_{short} = \frac{\mathcal{E}}{r}$$



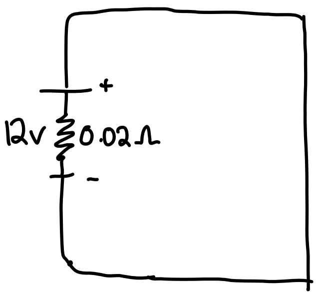
Notice:

This is the *maximum possible current* that this battery can produce!

i.e. 31.7: A short-circuited battery

What is the short-circuit current of a 12V car battery with an internal resistance of 0.020Ω?

What happens to the power supplied by the battery?



$12v - I(0.02\,\Omega) = 0$

$I = \frac{12v}{0.02\,\Omega}$

$I = 600\,A$

$P_r = I^2 r$

$= (600A)^2(0.02\,\Omega)$

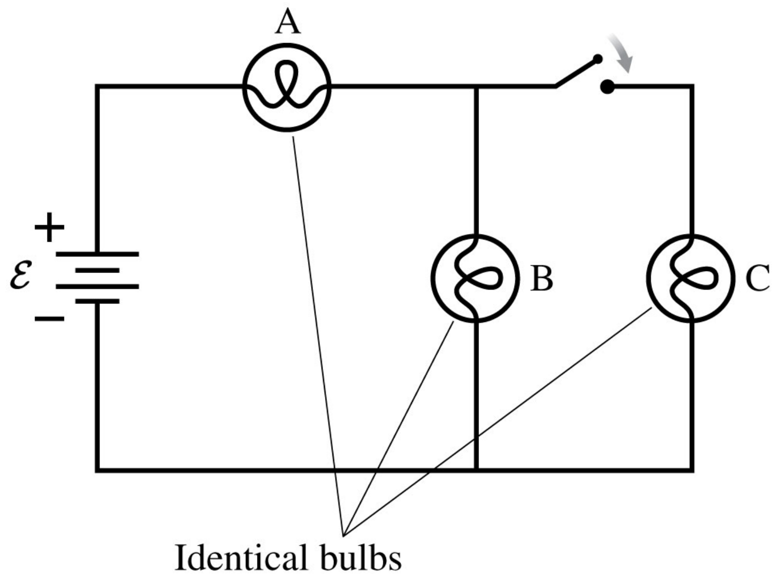
$P_r = 7.2\times10^3\,W$

7,200 W

Quiz Question 1

Consider the circuit below, where the switch is open. The current is the same through bulbs A and B, and they are equally bright. Bulb C is not glowing.

The switch is now closed, what happens to the brightness of A?

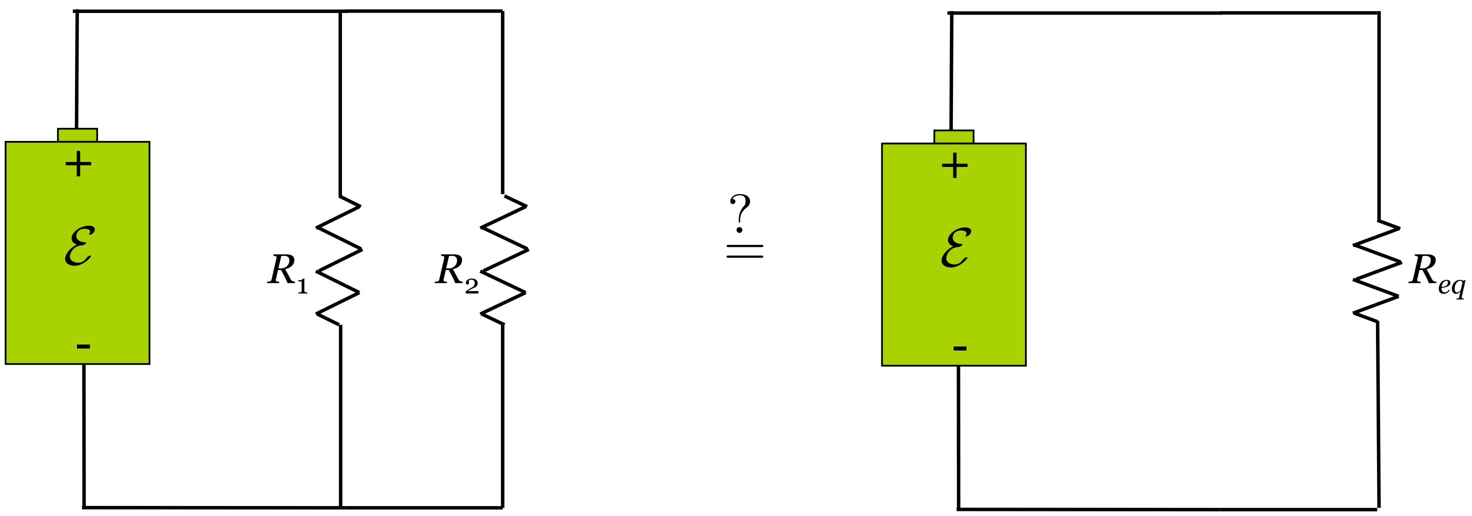


1. It increases.
2. It decreases.
3. It stays the same.

31.6:
Parallel Resistors

Consider two resistors in *parallel*…

- Can we find an *equivalent resistor*, R_{eq}, to the two resistors, R_1 & R_2?



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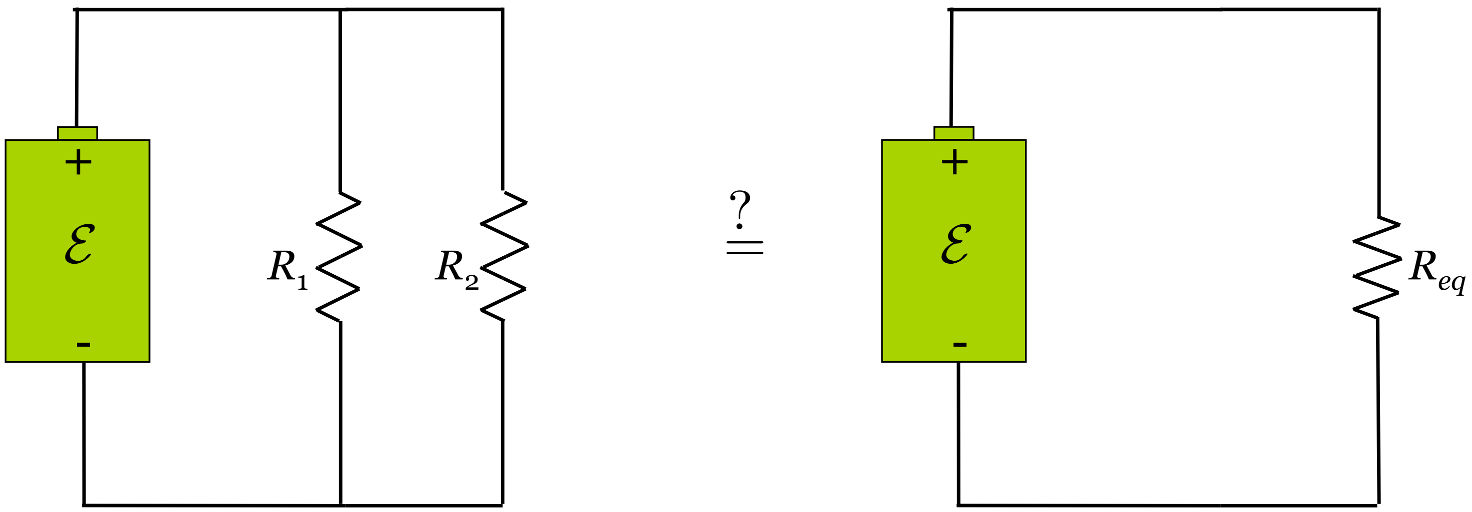


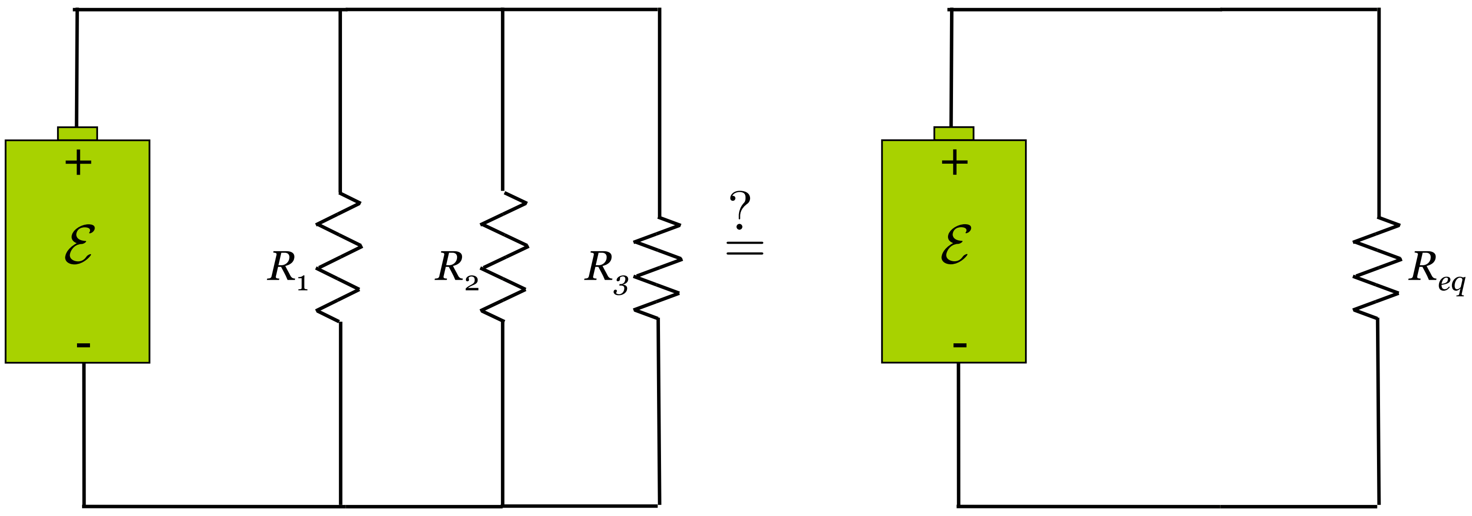
- YES!

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

31.6: Parallel Resistors

What about several resistors in *parallel*…

- Can we find an *equivalent resistor*, R_{eq}, to the the resistors, R_1, R_2,…(all in *parallel*)?



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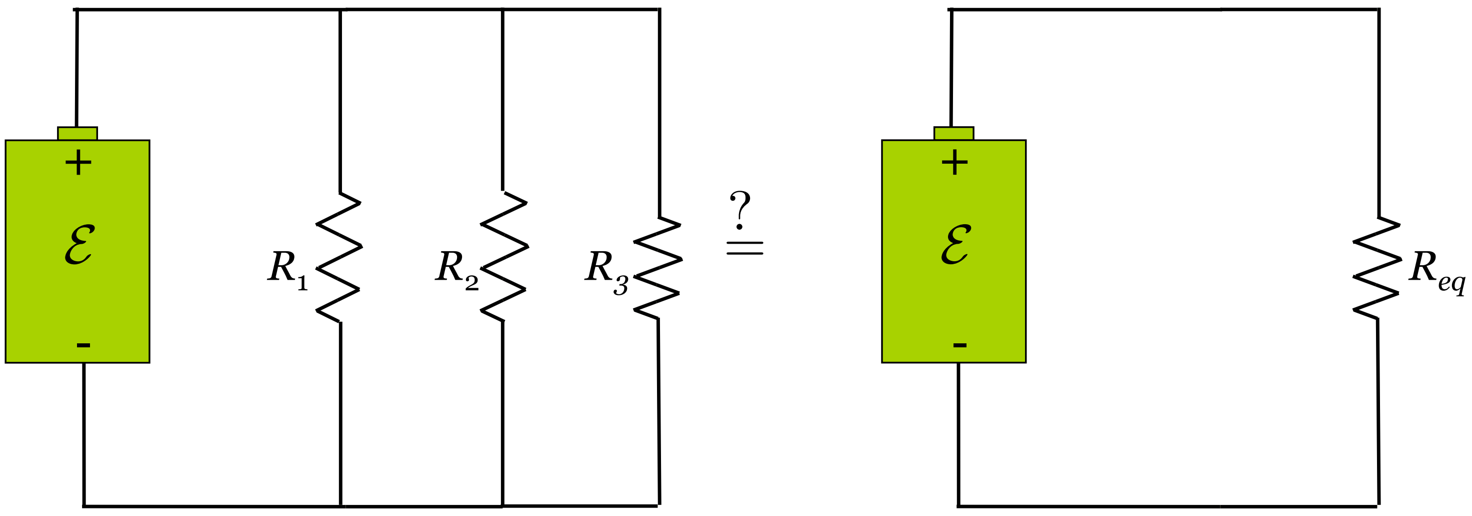


- YES!

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

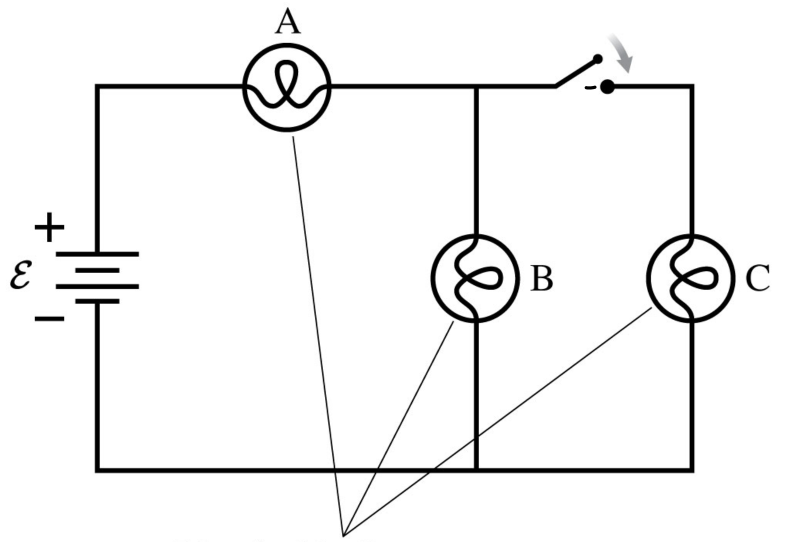
Quiz Question 1, continued..

Consider the circuit below, where the switch is open. The current is the same through bulbs A and B, and they are equally bright. Bulb C is not glowing.

The switch is now closed, what happens to the brightness of A?

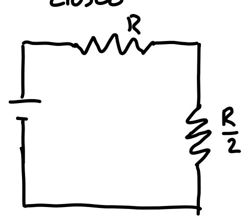
$\mathcal{E} - I(R+R) = 0$

$I = \frac{\mathcal{E}}{2R}$ ⇒ open



1. It increases.
2. It decreases.
3. It stays the same.

closed



$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R}$

$R_{eq} = \frac{R}{2}$

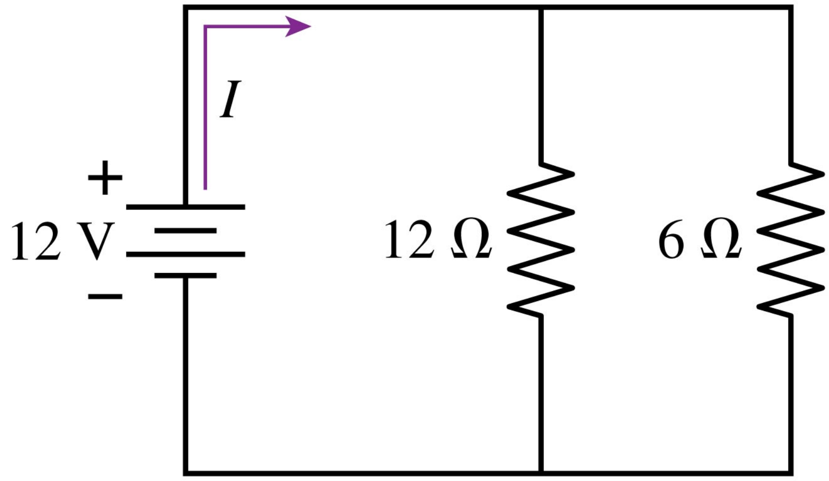
$\mathcal{E} - I(\frac{3}{2}R) = 0$

$I(\frac{3}{2}R) = \mathcal{E}$

$I = \frac{2}{3}\frac{\mathcal{E}}{R}$

Quiz Question 2

The battery current I is



1. 3 A.
2. 2 A.
3. 1 A.
4. 2/3 A.
5. 1/2 A.

$\frac{1}{R} = \frac{1}{12} + \frac{1}{6}$

$\frac{1}{R} = \frac{1}{12} + \frac{2}{12}$

$\frac{1}{R} = \frac{3}{12}$

$R = \left(\frac{12}{3}\right) = 4\Omega$

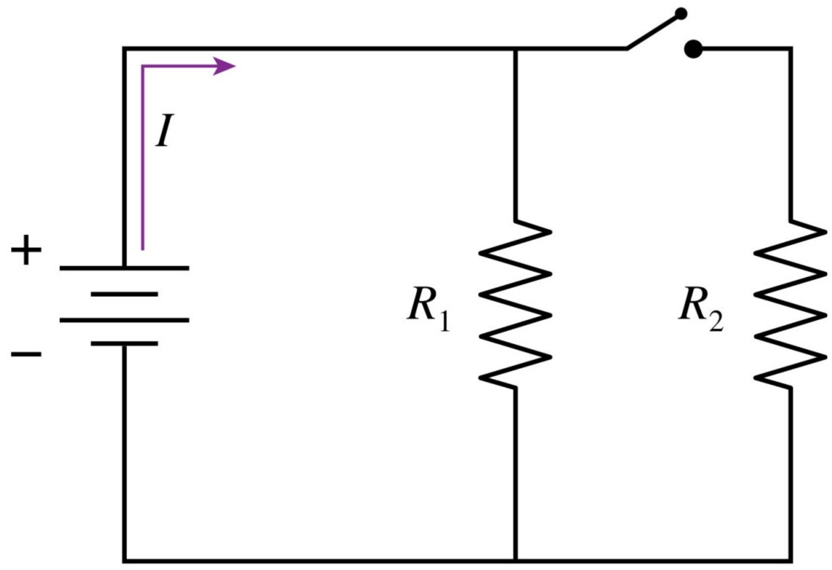
$I = \frac{\Delta V}{R}$

$I = \frac{12V}{4\Omega}$

$I = 3A$

Quiz Question 3

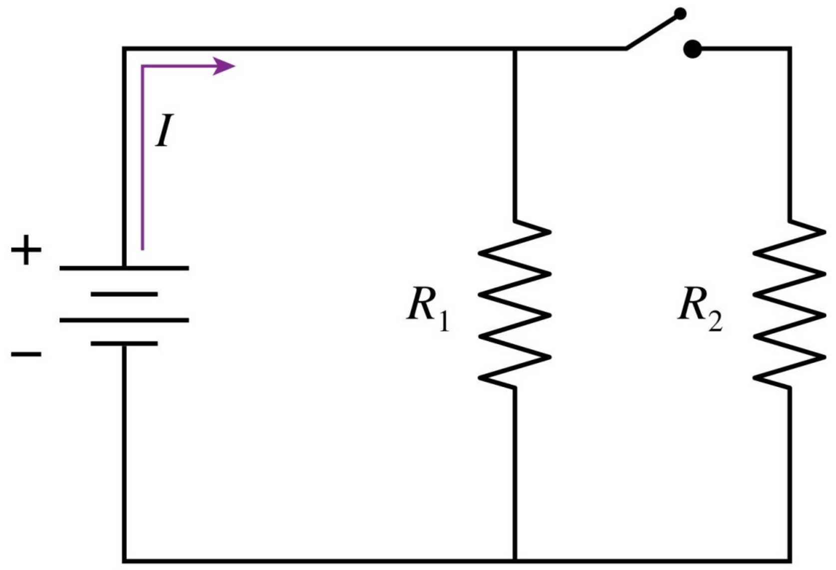
When the switch closes, the battery current



1. increases.
2. stays the same.
3. decreases.

Quiz Question 3

When the switch closes, the battery current



1. increases.
2. stays the same.
3. decreases.

Notice:

The equivalent of several resistors in parallel is *always less than* any single resistor in the group.